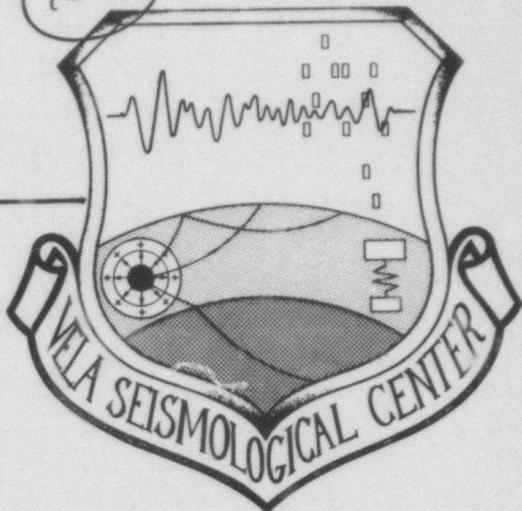


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LEVEL B2

**SEISMIC DATA ANALYSIS CENTER  
FINAL REPORT**



Robert R. Blandford  
Seismic Data Analysis Center  
Teledyne Geotech  
314 Montgomery Street  
Alexandria Virginia 22314

04 DEC 1981

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SEISMIC DATA ANALYSIS CENTER FINAL REPORT

SEISMIC DATA ANALYSIS CENTER REPORT NO.: SDAC-TR-79-7

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## ABSTRACT

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## I. INTRODUCTION

This final report summarizes work performed at the Seismic Data Analysis Center (SDAC) in Alexandria, Virginia from 1 October 1977 through 15 December 1978. Work at the SDAC was performed under contract number F08606-78-C-0007; this report fulfills data item A00A of the Contract Data Requirements List (CDRL).

Sections II through V of this report deal with the operations, programming, and maintenance of the SDAC Computer Services division, as well as data services provided for both in-house and external users of the data base. Section VI summarizes research projects completed during the contract and Section VII details accomplishments in VELANET development.

Routine computer operations continued on the SDAC systems during the contract period and system capabilities were expanded. In November, runs of the automatic association algorithm (AA) began to produce bulletins similar to bulletins produced by NEP analysts. Hardware for the Mass Store Data Retrieval System (MSDRS), purchased under the previous contract, was installed, and, in August, PSWF data was transferred from the Mass Store over the ARPANET to the PDP-11/70, stored on disk, displayed on the Tektronix graphics CRT, and plotted on the VERSATEC printer/plotter. In addition to enhanced software capabilities, the SDAC produced an initial draft of a design for an expanded seismic data analysis system to accommodate additional recording sites. Other significant developments that affected the data base included an end to the data flow from LASA and the start of data flow from the Pinedale, Wyoming seismic array (PWY). The major system operation problem was the continual user overload of the TS44 system. Correcting the problem required frequent disk maintenance and implementing more rigid accounting procedures to monitor use.

Several hardware maintenance problems developed during the contract period. The air-conditioning system functioned with few breakdowns, but only as a result of implementing a heavy maintenance schedule. The IBM 2400 Series tape drives malfunctioned constantly, causing delays in data processing, and the chronic problems affecting the PDP-11/35 interface with the IBM 360/40 caused delays in data analysis. A variety of problems, detailed in the maintenance section, hampered work on the PDP-15 computer.

Data Services continued to supply data to numerous agencies connected with the VELA program. Thirty-five different agencies and contractors received at least one shipment of requested information. In addition, several scientists visited the SDAC to use the data base. Significant accomplishments included program corrections and installation of the 9-track A/D system.

Numerous technical reports, technical memoranda, papers, and presentations relating to seismological research were written, and/or presented during the contract year. These papers dealt largely with the problems of magnitude vs. yield, discrimination techniques, and evaluation of seismic systems.

Under the task for VELANET development, efforts continued to create an automated digital system to receive, process, and store seismic data from remote sites. To fulfill this task, SDAC personnel expanded the capabilities of the Network Event Processing System, created the Final Event Summary List (an event list and location file), brought the Mass Store Data Retrieval System (the PDP-11/70) to operational status, and completed the Communications and Control Processor/Detection Processing System direct connection.

## II. OPERATIONS (Task 4.1)

This section of the report concerns operation of government furnished equipment including: 1) processors used in a real-time mode to receive and process data from remote seismic stations; 2) processors operating in the real-time mode to analyze and to store data from the real time system; 3) processors used in the "Batch" mode to support researchers and data specialists.

During the course of the contract, SDAC personnel operated the system 24 hours per day seven days per week. Seismic bulletins were created five days a week, except when equipment failed, and the results were sent to the mass store in Cambridge and to other agencies as directed by the Project Office.

The major problems affecting system operation were the overload of the TS44 and the chronic problems caused by the interface between the PDP-11/35 and the IBM 360/40. Heavy usage on the TS44 caused disk failures that frequently resulted in several hours of outage and lost research time. At other times heavy use delayed ILPA data transfers to the Datacomputer. In May of the contract period, 16% of the available computer time was lost because of component failures. Several of the outages spanned weekends, which the data services staff uses to fill requests. The interface problems frequently prevented routine Network Event Processing (NEP) and hampered other system development tasks.

Another problem that slowed data processing was failures in the DPS output tapes which caused tape read errors and eliminated end-of-file (EOF) records. These tape problems hindered NEP system processing.

The following tables provide data on system usage and reliability during the contract. Table I shows that the real time system was 95% reliable during this contract; the low was 84% in October and the high was 99% recorded in September. Most of the downtime was a result of crashes and preventive maintenance. The IBM 360/44 (Table II) was reliable 99% of the hours available under this contract. The computer operated under the TS system 85% of the available time. In terms of usage (Tables III and IV), Data Services accounted for 27% of the runs made and Texas Instruments accounted for 23% of the runs; system development efforts also accounted for 23% of the runs. For the IBM 360/40B (Table V), the NEP task continued to utilize most of the available computer time--79% of the total. Mass Store transfers accounted for 11% of the total. The PDP-15/50 (Table VI) continued to have only light use and was idle for 73% of the potential computer time. The new computer, the PDP-11/70 (Table VII), was used largely for system development, which accounted for 64% of available computer time. Research tasks, operations, and SDAC general usage accounted for a total of 28% of the time.

TABLE I  
Real Time System Performance (In Hours)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
<b>TOTAL POSSIBLE RECORDING HOURS</b>	744	720	744	720	672	744	720	744	720	744	744	720
<b>CCP Downtimes</b>	19.0	-	41.2	44.1	-	7.4	4.1	13.7	-	36.6	9.8	-
System Testing (BBN)	69.1	39.3	9.9	1.5	2.1	30.3	2.1	-	8.9	2.4	5.3	1.7
Preventive Maintenance	18.9	10.0	-	-	-	-	1.4	-	4.4	.1	.7	3.1
Software Training	-	-	5.4	1.9	3.6	5.3	26.5	3.6	4.8	3.9	2.0	4.3
System Crashes	11.8	-	-	-	-	-	-	-	-	-	-	.8
Other Problems	-	-	-	-	-	-	-	-	-	-	-	-
<b>Total Hours of Recording</b>	625	665	691	671	657	683	699	736	669	728	733	710
Total Percentage Recording Experience	84%	92%	93%	93%	98%	92%	97%	99%	93%	98%	98%	99%
<b>DP Downtimes</b>	9.5	8.0	7.0	6.0	3.8	2.6	2.0	5.3	2.9	1.9	2.2	4.2
Preventive Maintenance	-	9.0	7.0	1.5	-	8.1	10.9	4.8	4.1	7.3	6.1	6.4
Hardware Failure	87.8	36.1	39.5	56.0	25.3	40.4	50.5	26.9	2.9	-	12.6	28.0
Testing	15.6	-	-	-	.1	2.8	2.1	.6	.8	2.1	.7	1.6
System Crashes	-	-	-	-	.3	1.5	10.7	.2	-	1.8	2.7	-
Power Surges	-	-	-	-	-	.4	5.2	.8	4.3	.3	1.4	-
Operation Problems	-	-	-	-	-	-	-	-	-	-	.9	-
<b>Total Hours of Recording</b>	631	667	691	656	639	680	651	705	706	731	720	679
Total Percentage Recording Experience	85%	93%	93%	91%	95%	91%	90%	95%	98%	98%	97%	94%
System Average Reliability												93% Reliability

TABLE II  
Distribution of 360/44 Block Time (In Hours)

Classified	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Total Hours	Percentage of Total
System Development	02:00	15:30	09:00	02:30	02:00	04:00	06:00	-	06:00	01:00	03:30	04:00	56	1%
Down	04:30	07:30	00:30	-	-	-	-	-	-	-	-	-	13	-
TS44	34:00	50:00	21:00	19:00	61:00	55:00	22:00	121:30	11:30	36:00	08:30	95:30	535	6%
DOS	601:00	558:30	610:30	690:30	587:00	673:30	680:30	608:30	696:30	701:00	727:30	615:30	7750	85%
102:30	88:30	103:00	32:00	22:00	11:30	11:30	14:00	06:00	06:00	04:30	05:00	407	5%	
Total Hours Operating	710	670	723	683	611	689	698	623	709	708	735	624	97%	
Percentage of Total Hours Available/Month	95%	93%	97%	92%	91%	93%	96%	84%	98%	95%	99%	87%		

Total Hours Operating

Percentage of Total Hours Available/Month

TABLE III  
Distribution of 360/44 Block Time (In Runs)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept		Percentage of Total Runs
Data Services	1515	1089	1382	1624	1878	1947	1968	1870	2202	1804	2182	2126	27%	
Texas Instruments	1889	1555	1836	2004	1214	1731	1547	982	1555	868	1689	1208	23%	
Research	1218	1235	1630	1548	1656	1873	1069	1002	923	616	832	610	18%	
Batch Programming	355	285	322	419	495	452	503	470	333	155	185	203	5%	
Operations	26	66	41	27	48	79	90	127	57	53	55	125	.9%	
Systems Development	1090	1360	1547	1348	1029	1655	2008	1386	1571	1615	2177	1408	23%	
VSC	329	276	151	146	157	161	68	15	107	48	63	45	2%	
ENSCO	53	19	106	28	40	50	17	27	50	55	46	37	.6%	
VSC Priority	13	2	7	3	3	-	13	-	-	-	-	-	.4%	
NEP	3	1	-	5	115	12	1	68	13	7	41	63	.3%	
Total Runs	6491	5888	7022	7152	6635	7960	7284	5947	6811	5221	7270	5825		100% (Rounded)
													=	79506

TABLE IV  
Monthly Use of the TS44 System

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
Hours	744	720	744	743	672	744	720	744	720	744	744	720
Runs	6491	5888	7022	7152	6635	7960	7284	5947	6811	5221	7270	5825

TABLE V  
Summary of 360/40B Use

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Total Hours	Percentage of Total
Operations	11:00	31:00	09:00	17:00	13:00	20:00	27:00	15:00	06:30	10:00	07:00	11:00	178	3%
NEP	340:00	487	623:00	530:00	330:00	560:30	495:30	401:00	361:00	382:00	520:00	408:00	5439	79%
Data Services	03:30	01:30	00:30	02:30	05:00	01:30	00:30	02:00	03:00	01:00	—	—	21	—
DP	05:30	08:30	00:30	15:00	09:00	—	—	—	—	01:00	—	12:30	68	1%
TI	18:00	09:00	02:00	—	—	—	—	—	—	—	—	—	29	—
Batch Programming	33:00	01:30	04:00	03:30	03:30	03:30	02:30	01:00	—	00:30	01:00	00:30	52	1%
ILPA Transfer Project	91:00	22:00	—	05:00	70:00	12:00	—	—	—	—	—	—	200	3%
Research	02:00	—	—	03:00	09:30	16:30	25:00	11:00	07:00	12:00	05:30	04:30	96	1%
VSC	—	—	00:15	06:30	03:00	01:30	03:00	—	—	—	—	—	14	—
Mass Store	—	—	51:00	83:30	53:00	82:00	105:00	87:00	53:00	70:00	58:00	105:00	748	11%
Total Hours	504	561	690	667	496	695	659	517	431	477	592	537	993	99%

TABLE VI  
PDP-15/50 Utilization (In Hours)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Total Hours	Percentage of Hours
Preventive Maintenance	N/A	N/A	Available	4%										
Systems Development	44:30	58:00	37:30	28:00	20:45	29:30	43:30	32:50	02:35	08:15	31:30	-	337	4%
User	52:00	64:00	58:00	51:00	78:35	99:30	102:00	54:00	59:10	49:10	47:00	37:10	752	9%
TI	87:30	81:00	60:30	71:00	98:10	80:00	84:00	90:13	129:15	80:20	103:30	56:30	1322	12%
A/D Conversions	29:00	39:30	40:00	23:00	21:00	14:00	20:00	03:00	00:45	00:55	-	-	191	2%
Idle	518:00	477:30	548:00	520:00	453:30	521:00	470:30	563:57	528:15	605:20	626:20	639:4	73%	
													8696	

TABLE VII  
PDP-11/70 Utilization (In Hours)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Total Hours	Percentage of Hours Available		
System Research	-	-	-	-	-	-	-	383:00	301:00	382:00	-	300:00	135:00	185:00	1686	64%
TI	-	-	-	-	-	-	27:00	1:00	14:00	-	1:00	111:00	182:30	336	13%	
Univ. of Illinois	-	-	-	-	-	-	36:00	3:00	34:00	-	43:00	3:00	13:00	132	5%	
SDAC General Usage	-	-	-	-	-	-	-	-	-	62:00	-	-	62	2%		
VSC	-	-	-	-	-	-	-	-	-	-	55:00	123:00	178	7%		
Lincoln Labs Operations	-	-	-	-	-	-	-	-	-	-	5:30	00:30	6	-		
											-	-	220	8%		

### III. PROGRAMMING (Task 4.2)

The programming staff at the SDAC developed, modified, and corrected programs for the Communications and Control Processor (CCP), two IBM 360/40 computers, an IBM 360/44, a DEC PDP-15/50, and a PDP-11/70. These systems routinely recorded and processed seismic data and supported the research efforts of the VELA Seismological Center (VSC), Texas Instruments, and Geotech. The system also satisfied requirements for Data Services activities. This chapter reviews the programming support for these systems.

#### CCP

The SDAC programming staff continued to maintain and to improve operation of the CCP throughout the contract year. The most significant changes in the system dealt with the data flow; LASA data stopped arriving July 1 and was replaced with data from the Pinedale, Wyoming site.

Other modifications and corrections were as follows:

- o The default SITE 2 trace display on the Tektronix monitor was replaced with an Alaskan trace.
- o The NORSAR input module was corrected to prevent random information from being written into Type 10 messages sent to DP.
- o SAVMSG command was generated to save input data from multiple sites and output data to a single site.
- o A new DUMPIT command was generated to automate dumping multiple messages to the console.
- o The VELANET protocol modules were changed to: process Type 8 status messages and print them on the console; mark VELANET nodes dead or alive and print a message on the console; process messages with sequence number of 0, which signifies a data stream reset from a sending node.
- o A new operator command was implemented to print the current version number and the time of the last CCP restart.
- o A lock was installed on the front panel to prevent accidental system restarts caused by brushing against touch-sensitive switches.

- o Programming required to modify the 12 to 16 bit conversion algorithm for data transmissions to PAFB was completed.
- o Code to handle Pinedale (PWY) data was implemented and successfully tested with simulated data.
- o The SDAC-44/CCP/PAFB ACSIII block transfer protocols were tested by sending both test data and actual Norway EPX data.
- o The CCP software was modified to remove LASA traces from the display, to correct an error in the default gains for Wyoming and Alaskan data, and to change the medium gain channel entry for Alaskan data in the channel table.
- o All code referring to LASA was removed from the CCP program.

The contract period ended with version #155 of the CCP.

#### 360/40A (DPS)

The IBM 360/40A continued to run the real time Detection Processing System (DPS) throughout the contract period. This process is continuous and requires seismic data to be recorded and processed 24 hours per day, seven days per week. The processing consists largely of seismic signal detections occurring as data flows through the system and then recording these detections for later seismic analysis.

System modifications and corrections implemented during the contract period were as follows:

- o NORSAR EP results were received and processed by DPS.
- o A DP tape error, which caused difficulties with the NEP waveform data base building program was corrected.
- o Programs to handle status messages were written and incorporated into DPS.
- o To alleviate the near saturation of the 360/40, the ARPANET protocol software was removed from the DPS. The protocol was not needed with the direct connection to the CCP and the removal of the protocol created additional processing time for the 360/40A.
- o A new DOS supervisor was installed on the 360/40A; it is identical to that used on the 360/40B but more efficiently handles interrupts.

- o Tests verified the ability of DPS to receive and to record an additional ALK site.
- o The problem of DPS' entering a continuous RIT overflow loop was resolved.
- o The DP tape dump program was expanded to handle the Type 0 and Type 8 records on DPS tapes. Later, character translation routines were added to the program.
- o An experimental deglitching algorithm was incorporated into the DPS that compares the absolute difference between two samples to a threshold value.

In addition to software modifications and corrections, lab personnel prepared two memos on system development. The first memo was a design for a microprocessor system to augment the DPS analysis function. The second memo focussed on the timing characteristics and important aspects of an FFT capability. Staff also devoted considerable time to discover the reasons for the low number of detections for one of the ALK channels.

#### 360/40B (NEP)

The 360/40B was dedicated to the Network Event Processor (NEP) task during the contract period. The NEP system receives data from DPS and creates seismic events through automatic association and computer-assisted human analysis. Among the most significant developments during the contract year was the development of a diagnostics program to debug program errors in the interface between the IBM 360 and the PDP-11/35 computers. This diagnostic program was essential in eliminating errors in the interface that prolonged system failures.

In addition to the diagnostics, SDAC personnel successfully developed the Preliminary Signal Waveform File (PSWF) and transferred data to the mass store facility in Cambridge. Also, the programmers developed three new versions of the NEP program. Version 4.0 featured station constant transfer from the

360 to the PDP-11, automatic waveform scaling on the graphics screen, and automatic PAQ insertion. Version 5.0, made operational in early December, included an improved Mass Store creation program and an improved procedure to deal with unusual conditions during travel time computations. Version 6.0 was implemented in June; it included improvements in waveform building and disk reassessments. During the same month, four additional (for a total of six) disk packs became available for the analyst's sessions.

Other programming additions and modifications to the operational version of this system were as follows:

- o CPESF (Create PESF) was modified to limit the number of unassociated arrivals grouped with dummy events.
- o Programs were developed to create an EPX file that can be recovered by PAFB.

#### IBM 360/44 (Batch Processing)

The IBM 360/44 performs most of the batch processing done at the SDAC. In addition, this computer transmits seismic data entering the SDAC to Patrick Air Force Base. The most significant addition to this system during the contract year was the Summagraphics digitizer. This hardware converts graphic plots (seismograms) to digital tape. That is, it allows digital processing of a non-digital medium, which is a major factor in expediting data processing from the Area of Interest.

Other program additions and modifications were as follows:

- o HYPO was modified to allow 72 column input from terminals and to compute epicenters with only three stations.
- o NEWQC was modified to produce formatted printouts of the DPS Signal Arrival Queue records. It was later modified to direct data output outages to tape, allowing continued foreground execution.
- o SURVEY, which handles SRO tapes, was modified to correct several logic errors.

- o STALIST was generated to create formatted listings of the station coordinate file.
- o CVTDEC, a Fortran function, was added to the system library' it converts binary integers to characters.
- o SURVEY, NHYP071, TISSPROG, FETCH, TISEAR3H, TITDFILT, REPRO, SUBSETQC, FTT10/FTF10P, TIREAR, TIDBSMV1, INTAPE, DIGKRNCH, TISPROPRG, TILTPEDIT, TINEWSR0, and RATFOR, were cataloged.
- o NEWGEN was written and implemented to create labeled tapes for the DPS.
- o DPS source files and macros were installed in a directory.
- o NEWDP was cataloged for Data Services to allow a maximum of ten digit seismograms on an output SUBSET tape.
- o GROUVEL, which filters seismic data from SUBSET tape and also produces contour plots, was installed.
- o SIZE was enhanced to reflect accurate disk allocations for individual users.
- o QUICSAND was converted from DOS and cataloged for Data Services.
- o M7AY, a version of M7A, was modified to allow both long and short period data from KSRS to be processed in the same run.
- o PRENET was cataloged to reformat previous NETWORTH and NETPLOT input parameters into 72 character images for terminal input.
- o INTAPE was modified to allow users to limit the amount of data transferred during a read.
- o NETWORTH was modified to accurately calculate depth confidence intervals.
- o The STATUS command was enhanced to reflect the "queues held" condition.
- o MULOPT was written for Data Services; it is a generalized version of OUTPUT that allows creation of multiple output tapes during one job execution.

- o FIXPSWF was written to reformat PSWF records for transfer to the Mass Store.
- o HARKLOVE and HARKRAYL were written for ray path estimations.
- o EVENT44 was modified to retrieve data from ISRSPS event tapes.

In addition to these changes and additions, DPBEAM was modified several times. The staff corrected several errors and the program was modified to process data from Pinedale, Wyoming.

#### PDP-15/50

The PDP-15/50 is an interactive processor used by the research staff for A/D conversions, to evaluate data recorded by the Special Data Collection System (SDCS), and to study data from the Seismic Research Observatories (SRO). The most significant developments during the contract year were the addition of new tape drives and the installation of a 9-track A/D conversion system. The tape drives replaced the constantly malfunctioning Bucode drives, and the 9-track system made the operation of the PDP-15/50 compatible with the system on the IBM/360's.

Other program additions and modifications were as follows:

- o SDCS6 was updated to include graphics input instead of teletype input, a different default cursor, and a more flexible program design to accommodate further enhancements.
- o DUM (a task) was created to dump information in octal to the device assigned to logical unit 13. The task can be invoked either through console command or program request.
- o The RSX version of the A/D tape was debugged. It was later modified to write 9-track SUBSET tapes.
- o EBTOAS was written to translate an 8 bit EBCDIC character to a 7 bit ASCII character.

In addition to these changes, personnel devoted considerable effort to rebuilding the current version of the SDCS software. This effort was required because of disk crashes and bad tape backups.

### Digitizing Capability

In January the digitizer was successfully connected to the TS44 using the ARPANET. A foreground partition prints all points received from the digitizer. After resolving several software problems the digitizer routinely produced SUBSET tapes for the research staff.

### Documentation

The following programs and system enhancements were documented and either sent to VSC for approval or approved and published during the contract period:

	<u>CDRL</u> <u>Data Item</u>	<u>Date</u>
NEP Design Plan	A00F	18 July 1978
Design Plan--FESF, ILPA, & KSRS	A00F	9 August 1978
SDAC Maintenance Manual	A00E	12 December 1978
NEP System Description	A00L	19 December 1978
NEP System Specification	A00M	19 December 1978
NEP Analyst Guide	A00K	14 February 1979
SDAC Operations Manual	A00D	5 January 1979

#### IV. MAINTENANCE (Task 4.3)

During the contract period, Geotech personnel maintained the analog laboratory equipment, terminals, incremental plotters, timing systems, communications modems, ARPANET interfaces, the NEP graphics system and its interface, and the Communications Control Processor. Also, under this contract maintenance personnel assumed responsibility for the disk system on the PDP-11/70 and the Kennedy Disk Drives on the same computer. In addition to assisting with the installation of the PDP-11/70, staff devoted considerable effort to resolving recurring problems on the PDP-15/50, including A/D conversions, converting the 7-track tape system to a 9-track system, and installing new tape drives to replace the faulty Bucode tape drives. In August, accounting procedures were modified to more carefully detail maintenance effort expended on various tasks; the new system appears in the monthly reports.

The sections below separately discuss the various maintenance tasks.

##### Mass Store Data Retrieval System (PDP-11/70)

During the contract, all peripheral equipment was installed and SDAC maintenance personnel assumed responsibility for non-DEC equipment. Major hardware changes consisted of: modifications to accommodate the IMP-11A; installation of the Versatec printer/plotter; and the addition of 64K words of memory. Other maintenance was generally routine and included several servo adjustments on the Kennedy tape drives.

##### Analog Laboratory

The analog laboratory digitized a total of 1,064 seismograms, as well as numerous direct writes requested by researchers. The analog lab equipment required only routine maintenance, mostly calibrations, throughout the contract.

### The NEP Graphics System

The NEP graphics system consists of the Evans and Sutherland Picture System, a Digital Equipment PDP-11/35 model computer, and Ann Arbor alphanumeric terminal, a computer labs dual cartridge disk, a dual digital cassette unit, and a model 1140 interface to the IBM 360/40B computer.

Graphics System maintenance focused largely on problems caused by the interface between the PDP-11/35, which drives the E&S graphics screen, and the IBM 360/40. Initially, diagnosis of the problem was difficult because the software used to identify machine states was written before the problem occurred. To resolve this problem a new system excerciser was built in December, but still the problem was not resolved. Evans and Sutherland, which built the system, sent Geotech a diagnostics package in March to check the hardware and two Engineering Change Orders were installed to accommodate the package. At the same time, two consultants working with the programming section wrote a new software diagnostic program.

While software for the 11/35 computer system continued to cause problems, the hardware required only slightly more than routine maintenance. During July and August, the servo drive system on the 11/35 was repaired. The E&S screen required only routine maintenance.

### CCP

The Communications Control Processor generally functioned well during the contract period. The most significant change in the system was the addition of a new modem to accommodate Alaska and Wyoming data lines. Major maintenance tasks during the contract included repairing a broken cable between the CCP and the DPS, restoring power to one of the processor busses, and ending memory failures. Also, personnel devoted some effort to

repairing the interface to the IMP.

Other maintenance was generally routine and included repairs of the Silent 700 Terminals, the Tektronics hardcopy unit, and removing, replacing, and shifting HCL cards.

#### PDP-15/50

Maintenance staff at the SDAC assumed full responsibility for this computer during the contract, because DEC considered the equipment outdated and would not continue to maintain it. The most significant hardware changes was the installation of two 9100 Kennedy tape drives to replace the faulty Bucode drives. The installation took two weeks because of hardware problems in the Data formatter. The installation ended a long series of tape drive problems on the system. Other than routine maintenance also included a complete read/write skew alignment on the 7-track tape drives.

#### Terminals

The SDAC staff maintained five terminals in addition to those dedicated to the NEP graphics and CCP systems. The remaining terminals were maintained either by the manufacturer or the lessor. The only major task performed by lab personnel was the fabrication and installation of a terminal interface cable to the PDP-11/70.

#### Plotters

The aging plotters required extensive maintenance during the contract. The 14 inch plotter required continuous adjustments to eliminate poor character writing. Cables in both this and the 30 inch plotter had to be replaced several times. The only significant change in plotter location was the shift of 12 inch plotter to the IBM 360/44 room.

#### General Maintenance Tasks

In addition to other tasks, SDAC personnel continued to make repairs on the aging film viewers. During the contract new lenses were custom ordered, because none were available in the manufacturer's spare parts inventory. Also, roller bearings were installed in the machines to improve performance.

#### CONTRACT MAINTENANCE

##### Air Conditioners

A heavy maintenance schedule by the cooling contractor prevented major system failures during the summer months.

##### IBM Equipment

The IBM central processors and peripheral equipment continued to be generally reliable and IBM maintenance personnel provided responsible and effective on-call and routine maintenance.

##### Disk Systems

Both the Memorex 3660 and the Calcomp CD-14 disk systems were generally reliable during the contract period and required only routine maintenance.

## V. DATA SERVICES (Task 4.4)

Data Services provides information to contractors, government agencies, colleges, universities and investigators who are participating in studies or doing fundamental research relating to the VELA project. The services consist of extracting data sets from the seismic data archives, providing programs or routines to recover and process the digital data, and maintain records useful to data requestors concerning data formats, data availability, site information, and instrument characteristics.

Data are available on digital tapes, paper reproductions, film, and analog recordings. The data libraries consist of the archive of the 20 year LRSM experiment, the LASA data, much of the NORSAR data, and data from the SDCS. SRO and HGLP data are also copied and maintained in the archive. The real-time data recorded at the SDAC, KSRS, and ILPA are also stored and, as it becomes available, the NSS data will be merged into the SDAC data files.

Requests for data are satisfied in several ways. Copies of film can be made as well as paper reproductions of seismic data. Digital tapes are often simply copied and constitute the easiest request to satisfy. Analog to digital conversions are the most complex. A full time operator is available to do the conversions who is supported by others which pre-screen the data requests and perform quality control on the output.

From time to time certain research studies are proposed or contemplated which require exceptional effort from data services to develop a data base. The data base are usually very extensive and require lengthy computer runs and considerable bookkeeping and for the QC effort.

The data set created during this contract period consisted of events occurring in the Area of Interest over the time span of the data archived in the digital libraries.

The resulting data AI base consisted of around 150 events. Each event required between 10 and 15 hours of computer time to copy tapes from the numerous sites onto a tape containing data from many stations for a single event.

The contractors and government agencies that received information and other data during this contract period were:

AFTAC/TGS  
AFTAC/PAFB  
Albuquerque Seismological Laboratory  
California Institute of Technology  
Cambridge University  
CIRES  
Computer Science Corporation  
Cornell University  
Cooperative Institute for Research in Earth Science  
Institute de Physique du Globe  
Institute of Geological Sciences, Edinburgh  
Lamont Dougherty Observatory  
Lawrence Livermore Laboratory  
Lincoln Laboratories  
Los Alamos Scientific Laboratory  
New Mexico Institute of Technology  
NORSAR  
Northern Arizona State University  
Osservatorio Vesuviano  
Pennsylvania State University  
Roundout Associates  
Sandia Laboratory  
Southern Methodist University  
Southeastern Massachusetts University  
Stanford University  
Systems, Science, and Software  
Tennessee Valley Authority  
United Kingdom Atomic Energy Authority  
United States Geological Survey, Albuquerque  
Universitat Fridericiana Karlsruhe  
University of British Columbia  
University of California, San Diego  
University of Edinburgh  
University of Texas, Galveston  
World Data Center

The SDAC provided facilities to visiting scientists who wanted to use the seismic data base. Film viewers, computer resources, office space, services of a librarian, and reproduction equipment were made available.

Major accomplishments during the contract included: 1) updating seismicity files as data became available; 2) almost eliminating the A/D conversion backlog; 3) uncovering a major error in DPBEAM that invalidated all NORSAR long-period data because the channels were improperly labeled; 4) completing and installing the new 9-track A/D system; 5) physical examination of digital tapes located near the analog processing equipment resulting in recovering 298 tapes for reuse; and, 6) rearranging the tape racks in the tape library near the 360/44 in order to make space for another 6,000 tapes.

## VI. SEISMOLOGICAL RESEARCH (Task 4.5)

During the contract period scientists and support personnel in the research section of the SDAC completed and placed in the publication process or distributed 13 reports. In addition, 24 technical memoranda were completed and 2 papers were cleared for distribution in the open literature or for oral presentation.

The technical reports were distributed to those on the government approved list and a copy sent to the National Technical Information Center for cataloging and distribution to other users. The memoranda were distributed to members of the research staff at the SDAC and at the VELA Seismological Center.

Summaries of the reports either completed and distributed or placed in the final stages of the publication process during the contract year are listed below followed by titles of papers cleared for presentation or publication in the open literature:

Ms Versus Yield of Underground Nuclear Explosions at the Nevada Test Sites  
(SDAC-TR-76-11)

This report has been classified SECRET.

Study of Selected Events in The  
Baikal Rift Zone in a Seismic Discrimination  
Context  
(SDAC-TR-77-5)

Six events from the Baikal rift zone, which occurred between 1971 and 1975, were examined in a seismic discrimination context. Seismograms from ALPA, LASA, NORSAR, HGLP, the WWSSN, and the SRO stations for source mechanism,  $M_s$ - $m_b$ , corner frequency, pP, were compared to six east Kazakh explosions and the Aleutian explosions, MILROW. The discriminants proved useful in this study, except possibly the short-period spectral ratio, would not give correct discrimination for a shot array.

Study of Selected Events in the Caucasus  
In a Seismic Discrimination Context  
(SDAC-TR-77-6)

Eight earthquakes from the Caucasus occurring from 1971 to 1975 were examined in a seismic discrimination context. Seismograms from ALPA, LASA, NORSAR, and the HGLP and the WWSSN stations were studied for source mechanism,  $M_g - m_b$ , corner frequency, pP, complexity, and spectral ratio. All the Caucasus events can be identified as earthquakes by means of pP and  $M_g:m_b$  as compared to Kazakh and southwest USSR explosions. However, these discriminants could be spoofed for these events and for these data sources by means of a shot array.

On Detecting and Estimating Multiple  
Arrivals from Underground Nuclear Explosions  
(SDAC-TR-77-8)

Nine explosions have been used to study the problem of specifying the number and characteristics of the arrival phases of a nuclear explosion. Tentative identification of the amplitudes and time delays of the multiple arrivals are given. The results demonstrated that pP was present along with additional multiple arrivals indicated by other peaks in the likelihood function, L. Fair to good agreement existed between predicted and observed explosion periods measured on WWSSN long-period film and on LRSM short-period data deconvolved to appear as if recorded on the WWSSN system.

Seismic Discrimination of Earthquakes  
And Explosions, with Application to the Southwestern United States  
(SDAC-TR-77-10)

This study examines seismic discrimination of underground nuclear explosions from earthquakes in the Southwestern United States. The study included a survey of literature and research which preceded a presentation of the seismic discrimination parameters computed for a study of events in the Southwest and a series of experiments with multi-dimensional discrimination.

In general, seismic discriminant parameters obtained from the recording reflected the theoretical expectation of earthquake-explosion differences. Path-station effects were large for every parameter, especially for short-period data. Love-wave magnitudes were a superior discriminant when plotted versus  $m_b$ . Shear waves, if measurable, were also excellent. The common  $M_g - m_b$  plot shows three earthquakes with anomalously low  $M_g:m_b$  - the Denver earthquake, a Benham aftershock, and a Baja California earthquake.

However, multi-dimensional discrimination using network averages for parameters was superior to using either single-station parameters or linear combinations of the discrimination functions of individual stations.

A Study of Amplitude Variations and  $m_b$   
Bias at LASA Subarrays  
(SDAC-TR-77-11)

LASA subarray amplitude anomalies were investigated using 395 medium-sized events, distributed in ten azimuthally divided sectors. Although LASA magnitudes, when averaged over all azimuths, were only slightly biased relative to NEIS magnitudes, the amount of bias varied with azimuth and subarray, suggesting that a simple station correction for  $m_b$  bias is not adequate. Using a fixed effects model, the authors attempted to separate the cause of  $m_b$  bias into sector (azimuth) effect, subarray effect, and subarray-sector interaction. The event magnitude uncertainty could probably be reduced by network averaging, or by non-statistical detailed crustal and mantle structure which could be analyzed by ray-tracing to remove receiver effects.

The Effects of Spall on  $m_b$  and  $M_s$   
(SDAC-TR-77-12)

This study examined near-field observations of spalling and attempts to estimate its effects on  $m_b$  and  $M_s$ . Observations of spall on near-field accelerometers and particle velocity were used to study possible relationships between radius of spallation, estimated spall thickness, maximum height of spall at the surface, and shot depth of burial and yield. The total spall energy, the sum of many spall closures, is probably much smaller than the spall energy calculated for a single spall closure. The subsurface accelerometer data showed little, if any, spall energy leaving the source region, suggesting that spall has little effect on  $m_b$  and  $M_s$  at teleseismic distances.

Method of Automating Routine Analysis Tasks  
In Preparing a Global Seismic Bulletin  
(SDAC-TR-77-13)

Although it permits more rapid seismic data processing than before being implemented, the Network Event Processing (NEP) system at the Seismic Data Analysis Center could still perform more routine analysis tasks automatically. This report discussed these tasks, including: identification of false alarms in detection lists, timing of P and LR/LQ arrivals, associating seismic arrivals to events, depth-of-focus estimation, and measurement of magnitude.

Approaches to automating these tasks are presented, tested, and evaluated. Most of the methods are projected to take less time if done automatically than if by human analysts. In particular, the spectral estimation of  $m_b$  or  $M_s$  is found to be fast and reliable, correlating well with classical analysis estimates.

**Spectral Ratios for Explosions in Salt  
(SDAC-TR-78-1)**

Comparison of the P-wave spectra at common stations from the events GNOME, SALMON, and three nuclear tests in salt in the USSR shows that amplitudes are greatly enhanced by shallow burial. The scaling theory of Mueller and Murphy partially accounts for the enhancement, but there remain major differences between theory and observation, particularly at frequencies above 1 Hz. Effects of pP, consistent with a reflection coefficient of approximately 0.5, can be seen in the spectral ratios.

**Evidence of Spall from Deghosting Of  
Short-Period Teleseisms  
(SDAC-TR-78-2)**

Optimum deghosting for pP echoes improved the correlation between waveforms at common stations from underground nuclear tests located close to each other and deghosting both pP and Ps echoes improved the correlations and waveform match still more. Moreover, just as expected, the polarity for the optimum pP echoes was always negative and for the Ps echoes, positive.

Seismograms deghosted with these optimum echo parameters never achieved the correlation levels of KNICKERBOCKER and CHATEAUGAY which were detonated approximately 300 meters apart. Furthermore, the optimum echo parameters found at one station did not always increase the correlations between the same event pairs at other stations. Evidence exists that both the pP and Ps echoes are lowpass filtered versions of the P, rather than exact copies. This situation may exist because of topographical scattering for pP and a time distribution of the return of spall material for Ps.

**Random Scattering Effects on  
Rayleigh-Wave Amplitudes and Phases  
(SDAC-TR-78-3)**

Fluctuations in the amplitudes and phases of 20-sec Rayleigh waves were measured for ten earthquakes recorded at NORSAR and for two earthquakes recorded at an 1100-km long linear array in the southwestern United States. These measurements were compared with the prediction of Chernov (1962), who analyzed the scattering of elastic waves by random inhomogeneities along the source-to-receiver path. Use of this theory enabled the amplitude and phase fluctuations to be related to a statistical description of the random scattering medium. As predicted, it was found that the fluctuations were correlated over a longer distance in the direction parallel to the propagation of the wavefront than in the direction perpendicular to it. This implies by reciprocity that relative Ms within a test site would be better determined at a station in line with the vector between two events than by a station perpendicular to the vector. Certain measurements were incompatible with Chernov's theory, however; these discrepancies may be attributable to multi-path arrivals and/or large-amplitude scattering for which the Born approximation is not valid.

It was found that narrow-band spectral measurements of Rayleigh wave amplitudes exhibited stronger fluctuations across both arrays than did visual measurements of  $M_s$ . The size of the fluctuations was diminished by using broad-band spectra. Fluctuations in  $M_s$  are approximately 1/3 those in  $m_b$  across equivalent array dimensions. By reciprocity this implies that relative yields within a test site may be determined by using  $M_s$  with a standard deviation 1/3 of that obtained from  $m_b$  if an equivalent number of station measurements are available.

Random scattering of Rayleigh waves has a larger effect upon narrow-band measurements of attenuation than upon measurements of phase velocity. As a result of such scattering, surface-wave spectra may display significant fluctuations at various frequencies, causing source mechanisms inferred from spectral observations at only a few stations to be unreliable.

Results of the NTS Experiment Phase II  
(SDAC-TR-78-4)

Analysis of the enlarged set of Special Data Collection System (SDCS) data showed that all P waves observed in the WUS (Western United States) showed a significant loss of high frequency energy compared to losses at the Canadian Station RKON. While magnitude differentials at most WUS stations conformed to previously reported WUS-EUS (Eastern United States) bias patterns after crustal amplification corrections have been made, Nevada Test Site (NTS) stations showed higher amplitudes than expected on the basis of their  $t^*$  data. Still, they were significantly lower in amplitude than RKON's. At present this can only be explained by local focusing.

Analysis of Selected Seismic Events From  
Asia in a Seismic Discrimination Context  
(SDAC-TR-78-5)

This study examines earthquakes in Kamchatka, the Tien Shan, the Pamirs, the Baikal rift zone, and the Caucasus and explosions in the Aleutians, East Kazakh, West Kazakh, Southwest Russia, Lop Nor, and Baikal in a seismic discrimination context. Because of their low magnitudes ( $m_b$  from 4.2 to 6.0 and  $M_s$  from 3.2 to 5.8) and their varying propagation effects it was impossible on the basis of first motions or LR amplitudes to determine source mechanisms for most of the earthquakes. Seismograms from the arrays ALPA, LASA, and NORSAR, the HGLP and the WWSSN stations were analyzed for  $m_b$ ,  $M_s$ , LASA, and NORSAR, the HGLP and the WWSSN stations were analyzed for  $m_b$ ,  $M_s$ , corner frequency, long-period spectral level, long-period and short-period body-wave excitation, complexities, spectral ratios, radiation patterns, depth of focus, and higher-mode surface waves. The major successful discriminants for our data set were found to be  $M_s - m_b$  and identification of pP. In a stepwise linear discrimination analysis using the discrimination parameters  $m_b$ ,  $M_s$ , corner frequency, complexity, spectral ratio, and long-period spectral level, the earthquakes were separate from the explosions with high confidence.

Short Period S Wave Attenuation Under  
The United States  
(SDAC-TR-78-6)

Investigation of short period S wave spectra revealed severe attenuation of high frequency energy under the Western United States (WUS). The average  $t^*_s$  (for short period S) is about three times that of P, indicating that most - if not all - anelastic losses occur in shear deformation. The  $t^*_s$  for the Nevada Test Site appeared to be similar to the rest of the WUS.

Detection of Depth Phases  
Using Computer Graphics  
(SDAC-TR-78-8)

From a dataset of 116 earthquakes, all available SRO (Special Research Observatory) and PSWF (Preliminary Signal Waveform File) waveforms were presented on an interactive computer graphics screen and then examined for presence of depth phases pP, sP and PcP. Using the results, a focal depth for 66% of the total was postulated. About half of these, or 37%, agreed with depths published by NEP (Network Event Processor) or PDE (Preliminary Determination of Epicenter) bulletins. Earthquakes of magnitude  $m_b > 5$  are likely to produce clear depth phases. Rapid routine processing of a large number of events by the aligned-on-P method can be achieved with interactive computer graphics.

Description and Evaluation of the  
SDAC Network Event Processing (NEP) System  
(SDAC-TR-78-10)

This report is classified SECRET pending classification review.

Some Aspects of Lg and Pg Propagation  
(SDAC-TR-78-11)

Lg and Pg (P) wavetrains consist of S and P waves trapped in the continental crust. The modal structure of these waves can be approximated from ray-tracing and Brune's (1964) constructive interference criteria for normal modes. Ray theory arguments show that the modes involved in Lg and Pg propagation are extremely sensitive to internal random inhomogeneities in the crust and small deviations of the free surface or the Moho from plane parallel surfaces.

Evaluation of the Communications  
Control Processor  
(VSC-TR-81-7)

This report evaluates the role of the Pluribus, a multiprocessor/multibus system, in its role as the communications control processor (CCP) at the Seismic Data Analysis Center (SDAC) over the 26 months from its installation in April 1977 through May 1979.

In capacity the six processor Pluribus at the SDAC provides a bandwidth somewhat greater than 750,000 instructions per second, equivalent to three processors working full time. For the 16.8 KB/sec input and 28.2 KB/sec output data streams at SDAC operating in May 1979 this capacity is in excess of double the bandwidth required.

The hardware reliability of the Pluribus lives up to its billing. However, the system suffered over 8% downtime, primarily due to software problems. The CCP is in an R&D environment at SDAC which required revisions of the CCP inputs and functions over the 26 months of operation studied.

Other functions in addition to its CCP functions, such as data recording and signal processing, are not recommended for the Pluribus. Although the Pluribus has the wide bandwidth and the high reliability required for these functions, it was designed primarily for communications and so lacks a file management system necessary to support disks and tapes for data recording. It also lacks a higher level language. As such the Pluribus is a difficult computer to program. Consequently, generating multiple versions of signal detection algorithms (to enable testing one against another) would be expensive and apt to have an adverse impact on the system reliability.

TECHNICAL MEMORANDA

During the contract period, the following memoranda were completed and distributed:

- "Regional Discrimination Results", dated 31 January 1978.
- "The Use of VELA Array Data for Analysis of Seismic Data at Regional Distances", dated 29 March 1978.
- "Operating Time Needed for SDCS Stations", dated 24 March 1978.
- "An Analysis Approach for the Data Services Operations", dated 17 March 1978.
- "Character Strings in FORTRAN", dated 9 March 1978.
- "Needed Operational Duration for the Existing SDCS Stations", dated 7 March 1978.
- "LASA and ALK DP Scaling Update", dated 8 February 1978.
- "Floating Point Processor", dated 8 February 1978.
- "LASA and ALK DP Scaling Updates", dated 3 February 1978.
- "Distribution of AI Data Set Events in SDAC Subset Format", dated 26 January 1978.
- "Relationship Between the Station Magnitude and  $t^*$  Differentials and Their Bearing on the Results of the NTS Experiments", dated 5 January 1978.
- "Modal Simulation of High Frequency Crustal Phases", dated 28 December 1978.
- "The AI Data Set", dated 14 December 1977.
- "Investigation of Alaskan Array DP Detections", dated 2 December 1977.
- "Russian Seismograms", dated 4 August 1978.
- "Evaluation of Soviet Station Data", dated 8 August 1978.
- "Real-Time Data Glitches and Post-DP", dated 26 June 1978.
- "NORSAR Long-Period Data", dated 8 June 1978.

"Array Design for Regional Phases", dated 1 June 1978.

"Evaluation of LA0 and ALK-Online Detections for 02 March 1978  
(Day 61)", dated 25 April 1978.

"Release of Tectronic Strain Energy by PILEDRIVER", dated  
25 September 1978.

"Test New 9-Track A/D System", dated 21 September 1978.

"DP Scaling Experiments and Despiking Algorithm", dated  
7 September 1978.

"Use of AEDS Digitized Data in Regional Discrimination Studies",  
dated 5 September 1978.

In addition to these memoranda, the SDAC published a regular monthly letter summarizing that period's efforts to complete research and system development tasks.

PAPERS CLEARED FOR PUBLICATION IN THE OPEN  
LITERATURE OR FOR ORAL PRESENTATION

"Applications of Surface-Wave Ray Tracing", clearance received  
4 April 1978.

"Comments on the Use of Truncated Distribution Theory for Improved  
Magnitude Estimation", clearance received 4 April 1978.

## VII. VELANET DEVELOPMENT (Task 4.6)

The objective of the work described in this section is to create an automatic digital system capable of receiving, processing, and storing seismic data from remote recording sites. The system consists of the revised LASA Processing System (LASAPS), the Detection Processing System, and the Network Event Processor. This section summarizes efforts to fulfill this task during the contract period.

### NEP (Task 4.6.2)

Development continued on the Network Event Processing System, which was made operational during the previous contract. The most significant software change was the implementation of the Automatic Association (AA) program, which automatically creates events from DP System recordings. The results of the AA processing were incorporated into the NEP PAQ and EWF files for use by the seismic analysts. Beginning 27 November, the AA program was run daily and results made available for evaluation. In December, the program was modified to determine when an event is located in the area of interest. Near the end of the contract period new versions of AA were cataloged to execute in the foreground partition and the analysts ran and approved acceptance tests.

Other significant software developments during the contract period were as follows:

- o The PSWF creation program was integrated into the PESF creation. It was expanded to handle ALK data, 20 sps data, and the new station constants file.
- o A cross reference program that operates on the NEP relocatable libraries was designed, coded, tested, and made operational.

- o The NEIS BULLETIN program was modified to correct a problem in handling the change of year.
- o The ANALYST'S WORKSHEET program was modified to display the S/N ratios of ALK detections to the analyst.
- o Programs to plot NORSAR EPX results were updated to the current EPX format.
- o Investigations into beaming and rotating LP waveforms resulted in a set of functional specifications for enhancing the LP capabilities of the NEP System.
- o The SET option for horizontal gain and an enhancement to suppress automatic waveform scaling during scrolling were implemented.
- o Changes became operational to the NEP Waveform Building program to implement the off-line waveform build capability and DOS foreground operation.
- o A new DOS Supervisor was completed to handle the foreground batch processing required by the FG WFBUILD concept. WFBUILD was cataloged to run in a foreground partition.
- o Phase prediction code for SP and LP were completed.
- o The command REMOVE was implemented to remove traces from the screen.
- o The automatic period correction software was installed in the graphics task.

FESF, ILPA/KSRS (Tasks 4.6.3 and 4.6.4)

The Final Event Summary List (FESF) is intended to produce an event list and location file for storage on the mass store computer in Cambridge, Massachusetts. The list and file contains all available arrival information from all sources that provide data to the SDAC. The goal is to produce the most complete event list possible and the most refined location information possible and to make this information available to the seismic community.

The most significant development for this task during the contract period was completion of a design plan to create the files. The document was produced in a workbook format to facilitate updating as required; three updates were produced in addition to the original document.

Other important developments during the contract period were as follows:

- o Routine computer runs for the creation of integrated ESF and SWF began in November.
- o Procedures were created to develop a systematic tape library archive of ESF/SWF data.
- o The Signal Waveform Channel List File (SWCLF) was demonstrated in July and included both the program to maintain the file and the first version of the data in the SWCLF.
- o PREDICTOR was demonstrated at the end of the contract period.

PDP-11/70 (Mass Store Data Retrieval System, MSDRS - Task 4.6.5)

The PDP-11/70 is the computer that sends seismic data to and receives data from the Datacomputer mass store device located at the Computer Corporation of America facility in Cambridge, Massachusetts. The MSDRS is intended to provide a seismic data base for use by the seismic community to carry out research projects. The data is comprised of signals received and processed at the SDAC.

Work on the MSDRS was performed under amendment 8 to VT/7709. At the start of the contract period most of the essential components for the system had been received, including: the 11/70 Main frame and support equipment, the RP04 disk, a LA30 typewriter console, RK05 equivalent disks (PERTEC), an IMP11A ARPANET interface, and TEKTRONIX terminals. While not

all components arrived until January, enough were available to create a basic system for hardware and software shakedown. A member of the technical staff spent about a month at Lincoln Laboratories learning the UNIX operating system. By January, the UNIX distribution system, enhanced with graphics from Lincoln Labs, became available to users. In February, an executable system was constructed using Lincoln Labs software, but no network access was established. The network problems, caused by a combination of hardware and software failures were corrected when Lincoln Labs and University of Illinois (UI developed the UNIX system) consultants visited the computer center to debug the system. Finally, in August PSWF data was transferred over the PDP-11/70, stored on disk, displayed on the Tektronix graphics CRT, and plotted on the VERSATEK printer/plotter. The contract period ended with efforts to implement a FORTRAN callable Data-computer interface and an evaluation of the integrity of the File Transfer Process (FTP).

CCP/DP Direct Connection (Task 4.6.6)

Efforts to complete the direct connection spanned the first five months of the contract period. In October, a test was made to determine the feasibility of using the UCSB ARPANET interface directly hooked to the CCP instead of the IMP; the test revealed that the DPS and the CCP could be directly connected using the UCSB interface. During November and December transfer paths were configured and software modifications made to support the direct link. In January, CCP-DPS acceptance testing began and the results indicated a stable system, except for a large number of retransmissions. This problem was resolved, and during February another acceptance test was run and the entire task successfully completed.

#### NEP Seismic Discrimination Package (Task 4.6.7)

During the first month of the contract period, an outline was made of the computational subroutines required to establish the capability to compute discrimination parameters in the NEP system. During the following months, detailed designs of the software began and final agreement of the parameter and record format was reached. In April programming efforts commenced to execute the routines to be used in the NEP Seismic Discrimination package. By the end of the contract period: 1) software implementation for the discrimination phase began; 2) required code revisions were being completed; and 3) the redesign of the frequency response curve within the discrimination code was completed and implementation began.

#### CCP Maintenance Station (Task 4.6.8)

Additional hardware was procured to augment the CCP. This equipment provides software and hardware personnel the ability to train, test, and develop programs for the CCP in an off-line mode of operation. The hardware also can be used as spares for the more critical CCP functions.

#### Evaluation of the Communications and Control Processor (Task 4.6.9)

This report evaluates the role of the Pluribus, a multiprocessor/multibus system, in its role as the communications control processor (CCP) at the Seismic Data Analysis Center (SDAC) over the 26 months from its installation in April 1977 through May 1979.

In capacity the six processor Pluribus at the SDAC provides a bandwidth somewhat greater than 750,000 instructions per second, equivalent to three processors working full time. For the 16.8 KB/sec input and 28.2 KB/sec output data streams at SDAC operating in May 1979 this capacity is in excess of double the bandwidth required.

The hardware reliability of the Pluribus lives up to its billing. However, the system suffered over 8% downtime, primarily due to software problems. The CCP is in an R&D environment at SDAC which required revisions of the CCP inputs and functions over the 26 months of operation studied.

Other functions in addition to its CCP functions, such as data recording and signal processing, are not recommended for the Pluribus. Although the Pluribus has the wide bandwidth and the high reliability required for these functions, it was designed primarily for communications and so lacks a file management system necessary to support disks and tapes for data recording. It also lacks a higher level language. As such the Pluribus is a difficult computer to program. Consequently generating multiple versions of signal detection algorithms, to enable testing one against the others, would be expensive and apt to have an adverse impact on the system reliability.

PDP-11/70 Data Retrieval System Expansion (Task 4.6.10)

Sixty-four thousand words of core memory and two 9-track tape drives were purchased and installed in the PDP-11/70 system.

National Seismic Station (NSS) Development (Task 4.6.11)

This task was completed under Amendment 10 to this contract. The purpose was to begin the effort to accept, record, and analyze data from a prototype station to gather data from the USSR.

#### VIII. DATA RETENTION (Task 4.7)

A plan for data retention was written in June and July and was included as part of the Design Plan submitted in fulfillment of Data Item A00F of the CDRL. As a result of the study, the contractor and the client determined that cost effectiveness ruled out the use of computer and staff resources to edit the real time data and place it onto tapes.